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## Appendix

Analyzed potential risk factors
- Age
- Diabetes
- Obesity
- Hyperlipidemia
- Hypertension
- Smoking
- Previous lung disease
- Symptomatic carotid stenosis
- Previous stroke
- Previous transient ischemic attack
- Previous peripheral atherosclerotic occlusive disease
- Previous carotid operation
- Bilateral carotid stenosis
- Severity of ipsilateral-contralateral carotid stenosis
- Previous myocardial infarction
- Previous cardiac decompensation
- Previous cardiac operation
- Number of diseased coronary vessels
- Number of CABGs
- Concomitant valve operation

## Commentary

Currently there is growing appreciation among many cardiac surgeons that patients with severe concomitant carotid and coronary artery disease are better treated with combined myocardial revascularization and carotid endarterectomy during one period of anesthesia. Given that decision, several surgical approaches have been suggested for technically performing the combined operation. In the majority of institutions the carotid endarterectomy is performed while the heart is still beating before the institution of cardiopulmonary bypass (CPB). In 1977 Reis and Hannah[1] advocated performance of the carotid endarterectomy during CPB with significant hypothermia. Several reports with small numbers of patients have documented the results achieved with such an approach.[1-4] Schwartz and associates[2] compared patients having carotid endarterectomy before CPB with patients having carotid endarterectomy during CPB and could find no advantage to the latter technique.

In this issue of the *Journal*, Minami and coworkers report their early and late results with simultaneous carotid endarterectomy and coronary artery bypass grafting (CABG) during CPB in 340 patients. Minami and colleagues advocate a technique that entailed initial exposure of the carotid artery followed by a median sternotomy and institution of CPB at a blood temperature of 27°C. With the unloaded heart beating on CPB, the carotid endarterectomy was completed with the use of a vein patch. Myocardial revascularization was then performed during intermittent aortic crossclamping with an average of 2.9 grafts per patient. The neck incision was closed at the end of the procedure.

Cerebral function was monitored throughout the operation with continuous electroencephalography. Intraluminal shunts were used only in patients in whom the electroencephalograph demonstrated cerebral ischemia.

In this current series the early mortality rate of 2.6% and the neurologic complication rate of 4.7% (permanent deficits in 3.2%) are certainly comparable, as noted in the article, with early results reported from series in which the carotid endarterectomy was performed before CPB. Although the acuity of the patients' ischemic disease is not specifically described in the study, the complexity of the preoperative carotid evaluation, the relatively lower number of arteries revascularized, and the absence of ischemic acuity as a predictor of hospital mortality suggest that most of these patients were probably undergoing elective myocardial revascularization. The low mortality is probably in part a function of the younger age of the patients and the absence of acute ischemia with lesser degrees of coronary disease, as well as excellent technique by the authors. The low incidence of stroke can also be answered in part by less extensive generalized atherosclerosis in younger patients, particularly since their technique of myocardial preservation requires repeated applications of an aortic crossclamp, and most of the early strokes were ipsilateral to the carotid endarterectomy.

The long-term survival of 56.1% at 10 years is comparable with results from other series with patients of similar ages, and the late freedom from neurologic events of 78.9% at 10 years is somewhat lower than the 92.3% that my colleagues and I[5] reported several years ago.

Although the authors are to be commended for their excellent results, several questions arise concerning this approach. The first centers on the physiologic rationale for the authors' technique. Certainly systemic hypothermia to a blood temperature of 27°C will be neuroprotective to some extent for modest periods of time. Weiss and coworkers[4] strongly advised using hypothermia to much lower levels, specifically, 20°C. The neuroprotective effect of hypothermia is probably useful in ameliorating the potential negative effects of several other aspects of their technique; for example, the loss of true pulsatile perfusion on CPB. The authors state that the heart is unloaded during CPB and, therefore, the normal pulsatile pattern must be blunted. In addition, hypothermia in combination with anesthetic agents routinely produces generalized slowing of the electroencephalogram, which can mask cerebral ischemia that would normally also be revealed as slowing on the electroencephalogram. Thus the decision to place an intraluminal shunt may be delayed. Obviously, hypothermia would not completely mask asymmetric, lateralized slowing, but it might delay the recognition of its presentation. Their claim that hemodilution during CPB is also advantageous to cerebral protection is more difficult to understand.

Another question that arises concerning the authors' approach is whether there is a disadvantage to prolonging CPB to perform the carotid endarterectomy. Cardiac surgeons attempt to keep any period of CPB as short as is practical to safely complete the intended operation. Longer perfusion times cannot be an advantage. In this series there were only 2.9 coronary anastomoses per patient, a relatively low number compared with most series. CPB times for that portion of the operation should, therefore, be relatively short; thus the addition of the time to perform the carotid endarterectomy might be relatively less injurious.

Another feature of the authors' CPB technique that deserves comment is the degree of hypothermia that they use, namely, 27°C. Although the lower the temperature, the greater the general neuroprotective effect, this temperature is lower than many cardiac surgeons currently use to perform myocardial revascularization. Whether the added time to cool and rewarm or any potential deleterious effects of deeper hypothermia might have an impact on the results is unclear.

Our own experience with performing carotid endarterectomy before myocardial revascularization during CPB now extends to almost 500 patients. The average age of our patients approaches 70 years, and the average number of CABGs is about 4 per patient. Our mortality and neurologic results are comparable with those reported by the authors in similar patients. Although we believe we have almost neutralized carotid stenosis as a risk factor for ipsilateral stroke during myocardial revascularization, our principal neurologic problem now is the occurrence of contralateral or bilateral deficits in patients with extensive aortic atherosclerosis. Advanced patient age and acute ischemic coronary syndromes necessitating nonelective operations remain the strongest predictors of early mortality.

In summary, the operative approach to concomitant carotid and coronary disease of performing both revascularization procedures on CPB has achieved very good results in the authors' hands in their patient population. Whether this approach is equally applicable to older patients with more acute ischemia and with more extensive coronary and aortic atherosclerosis remains to be demonstrated.

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